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PALEONTOLOGY AND GEOLOGY OF THE BADWATER CREEK AREA, CENTRAL WYOMING. PART 18. REVISION OF LATE EOCENE *HYOPSODUS*

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ABSTRACT

Review of late Eocene *Hyopsodus* material, including a larger sample from Badwater, indicates that *Hyopsodus fastigatus* Russell and Wickenden, 1933, is conspecific with *Hyopsodus uintensis* Osborn, 1902. Material from Montana previously referred to *H. fastigatus* represents a new species of *Hyopsodus*.

INTRODUCTION

In the last major review of late Eocene *Hyopsodus*, Gazin (1968) recognized two species—*H. uintensis* Osborn, 1902, and *H. fastigatus* Russell and Wickenden, 1933—from sparse remains in Wyoming, Utah, Montana and Saskatchewan. Additional collecting from the series of Uintan Badwater localities has since enhanced this record. Analysis of these and other remains warrants revision of the systematics of late Eocene *Hyopsodus*. Also, the absence of a record of *Hyopsodus* from the Duchesnean Badwater locality 20—one of the best sampled of the Badwater sites—has significant paleoecological implications.

Osborn (1902) described *H. uintensis* from the holotype, a partial maxilla (AMNH 2079), and two fragmentary lower jaws (AMNH 2078, 2078a), all from Uinta C deposits, Utah. Gazin (1956, 1968) referred to this species material from the Badwater localities 5, 5A, 5 Front, 5 Back, 6, and 7, and six unnumbered specimens from the Uinta Basin in the CMNH, USNM, YPM, and MCZ collections. Of the latter, only

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the CM material is definitely known to have been recovered from the Uinta B White River Pocket locality. The provenance of the unnumbered *Hyopsodus* remains in the MCZ and USNM is probably the same, but the YPM material may be from either Uinta B or Uinta C sediments. Material identified as *Hyopsodus* cf. *uintensis* includes an isolated molar from the Beaver Divide Conglomerate (Gazin, 1956; Van Houten, 1964; Emry, 1975) and beautifully preserved dentitions from the Tepee Trail Formation, East Fork Basin, Wyoming (McKenna, 1972).

Russell and Wickenden (1933) identified a larger species, *H. fastigatus*, from four isolated lower molars from the Swift Current Creek beds, Saskatchewan. Later, Russell (1965) added four more isolated molars from the same deposits to the hypodigm and assigned three teeth to *Epihippus?* sp. Gazin (1968) referred to *H. fastigatus* more complete material from the Shoddy Springs locality, Climbing Arrow Formation, Montana, in the CMNH collections.

Analysis of this material, remains of Bridgerian *Hyopsodus*, as well as new collections from the Badwater Uintan deposits, implies that (1) in Russell's study (1965), one of the teeth identified as *H. fastigatus* does not belong to *Hyopsodus*, and two of the three alleged *Epihippus*? sp. teeth are upper molars of *Hyopsodus*; (2) the holotype and referred material of *H. fastigatus* from the Swift Current Creek beds are conspecific with *H. uintensis*; (3) the referred material of *H. fastigatus* from Montana represents a new species; and (4) collections of *Hyopsodus* from the Uinta B White River Pocket locality belong to *H. paulus*, hitherto known only from Bridgerian horizons.

Abbreviations used are as follows: AMNH, American Museum of Natural History; CMNH(CM), Carnegie Museum of Natural History; NMC, National Museum of Canada; ROM, Royal Ontario Museum; MCZ, Museum of Comparative Zoology, Harvard University; USNM, Smithsonian Institution; YPM, Yale Peabody Museum, Yale University; L, length; W, width; N, number; SD, standard deviation; CV, coefficient of variation. All measurements in text and tables are in millimeters.

SYSTEMATICS

Hyopsodus Leidy, 1870
Hyopsodus uintensis Osborn, 1902
(Figs. 1–5, Tables 1, 2)

Hyopsodus fastigatus Russell and Wickenden, 1933.
Hyopsodus, cf. *uintensis* Gazin, 1956.
Hyopsodus sp. Van Houten, 1964.
Hyopsodus fastigatus Russell, 1965 (in part).
Epihippus? sp. Russell, 1965 (in part).
Hyopsodus uintensis Gazin, 1968 (in part).
Hyopsodus cf. *H. uintensis* Emry, 1975.

Holotype.—AMNH 2079, partial right maxilla with P^4-M^3, Uinta Formation (Uinta C), Utah.

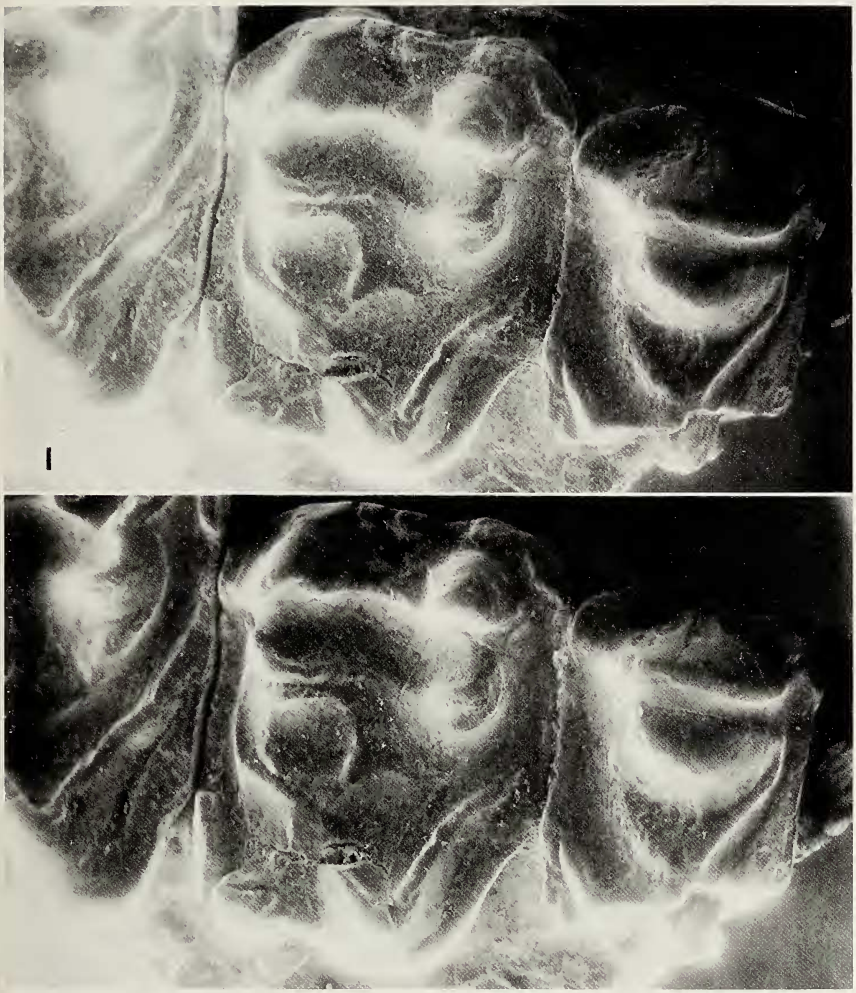


Fig. 1.—*Hyopsodus uintensis*, type, AMNH 2079 (part), RP^4M^1 part of M^2.

Referred specimens.—P_3-M_1, AMNH 2078; P_4-M_1, AMNH 2078a, CM 14576; M_{1-2}, CM 14418, 16860; M_{2-3}, CM 16054; P_4, CM 14520, 28864, 29210; M_1, CM 15250, 15256, 15252, 14574, 14521, 15251, 15265; M_2, CM 25325, 16816, 14523, 15253, 15246, 16857, 15262, 15264, 15263, ROM 1682, 1683, NMC 8654, 8655; M_3, CM 15247; P^{3-4}, CM 28865, 28889,; M^{1-3}, CM 14419, 21985; M^{2-3}, CM 18251; P^3, CM 29209; dP^4, CM 14524, 15254, 28843; M^1, CM 14458, 14519, 29026, 14752, 15248, 15249, 15255, 15257, 15260, 15261, 16858, 25323, 28840; USNM 21089, ROM 1681, 1686, 1687; M^2, CM 14514, 14515, 14517, 14518, 14575, 15556, 16859, 25324, 28838, 28839, USNM 23743, 181389; M^3, CM 14753, 15259, 16856, 19739, 25328, 28841, 28842, 28888, 29027.

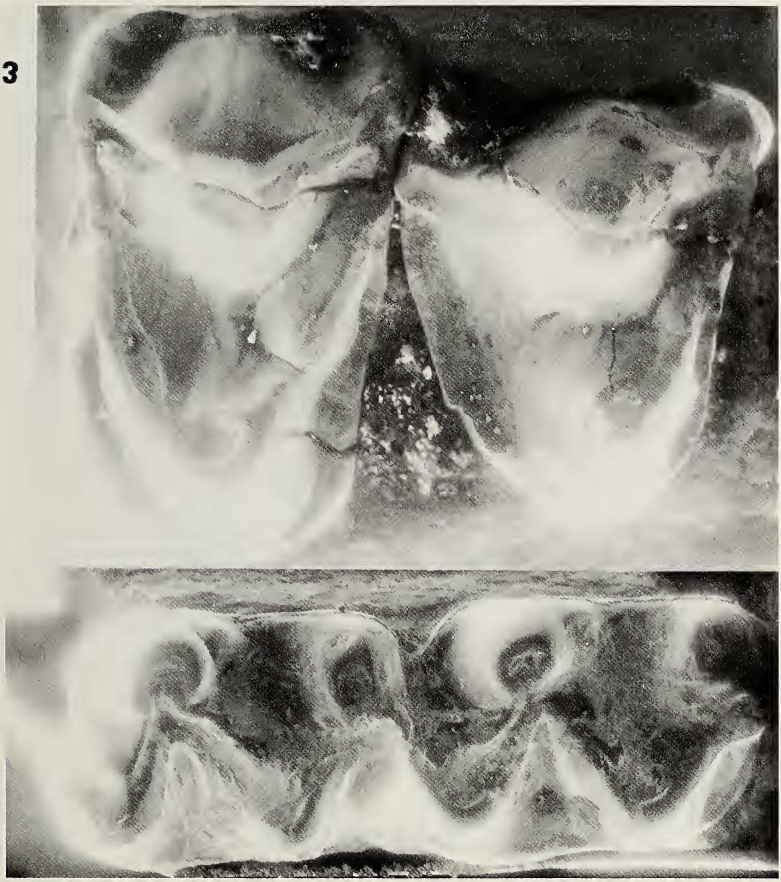
Localities.—Badwater localities 5, 5A, 5 Front, 5 Back, 6, 7, Hendry Ranch deposits,

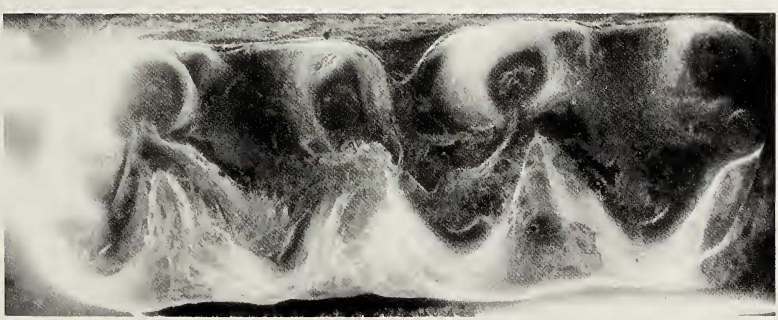
Fig. 2.—*Hyopsodus uintensis*, type, AMNH 2079 (part), RM^{2-3}.

Wyoming; Beaver Divide Conglomerate Member, Wiggins Formation, Wyoming; Swift Current Creek beds, Saskatchewan; Uinta Formation, Utah.

Known distribution.—Uintan of Wyoming, Utah, and Saskatchewan.

Emended diagnosis.—Differs from all previously described species of *Hyopsodus* as follows: P_{3-4} more molariform, with wider trigonid





Figs. 3–4.—*Hyopsodus uintensis*. 3) CM 28889, RP^{3-4}; 4) CM 14418, LM_{1-2}.

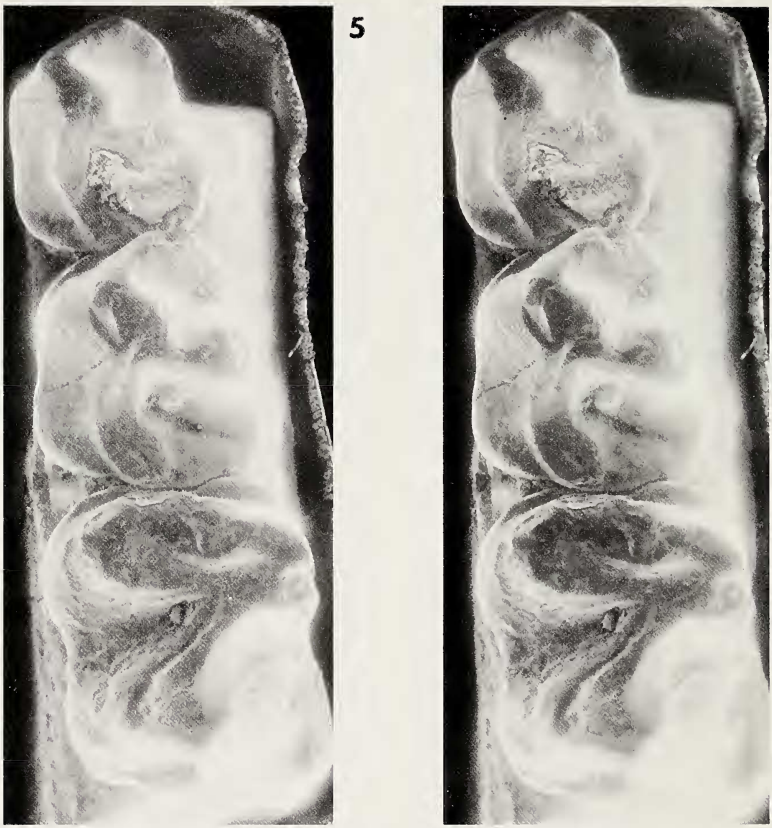


Fig. 5.—*Hyopsodus uintensis*, AMNH 2078, LP_3-M_1.

and talonid; on M_{1-3} trigonid oriented more obliquely, entoconid greatly enlarged, hypoconulid reduced, valley between these two cusps obliterated; P^{3-4} with broader postcingulum lingually, stronger preprotocrista; paraconule on P^4; M^{1-2} with hypocone almost as large as protocone; deep lingual valley completely separating two cusps and extending labially to metaconule; M^3 with wider hypoconal shelf; marked lophodonty on the molars. Significantly smaller than *H. sholemi*, new species (described below), with triangular P^3, shorter trigonid on P_{3-4}, narrower talonid on P_4 and more transverse M^{1-2}.

Remarks.—H. uintensis is derived with respect to all previously described species of *Hyopsodus* in the degree of molarization of the premolars, the degree of lophodonty on the molars, the deep valley separating the large hypocone and protocone on M^{1-2}, and the enlargement of the entoconid on M_{1-3}.

Table 1.—*Dimensions of upper teeth of* Hyopsodus uintensis *from Wyoming, Utah and Saskatchewan, and* H. sholemi *new species, from Montana.*

Teeth statistics	*Hyopsodus uintensis*		*Hyopsodus sholemi*	
	L	W	L	W
P^4 Range	3.0–3.1	5.1	3.4	5.6
Mean	3.066	5.1	—	—
Number	3	2	1	1
M^1 Range	4.0–4.6	4.9–5.7	5.0–5.1	6.4–6.5
Mean	4.368	5.363	5.066	6.466
Number	19	19	3	3
SD	0.1916	0.2564	—	—
CV	4.386	4.781	—	—
M^2 Range	4.1–4.9	5.7–6.6	5.0–5.1	7.1–7.5
Mean	4.538	6.213	5.066	7.333
Number	16	16	3	3
SD	0.2629	0.3052	—	—
CV	5.793	4.912	—	—
M^3 Range	3.5–3.8	4.5–5.5	3.6–4.4	6.0–6.8
Mean	3.656	5.191	4.025	6.325
Number	9	11	4	4
SD	0.1236	0.3207	—	—
CV	3.380	6.170	—	—

West (1979) has convincingly shown that Bridgerian material of *Hyopsodus* from the Green River Basin represents only three species, one of which is *H. paulus*. In these and known Wasatchian species of *Hyopsodus*, molar lophodonty is absent or weak, the hypocone on M^{1-2} is small, the protocone-hypocone valley is shallow so that a strong labial connection between the two cusps is maintained, and the entoconid on M_{1-3} is not enlarged.

Accordingly, CM 17150, the (previously unnumbered) partial maxilla from the Uinta B White River Pocket locality that Gazin (1968) identified as *H. uintensis* is referred to *H. paulus*, along with CM 14924, 19648, 19947, and 19948, additional material recovered from the same locality.

Similarly, the unnumbered specimens in the MCZ and YPM from the Uinta Basin that Gazin (1968) assigned to *H. uintensis* are identified here as *H. paulus*. There is no record of *Hyopsodus* material from the Uinta Basin in the USNM collections.

USNM 181398 from Beaver Divide is, as Gazin (1956) and Emry (1975) tentatively noted, an M^2 of *H. uintensis*.

Russell's (1965; Russell and Wickenden, 1933) recognition of *H. fastigatus* from isolated lower molars stemmed partly from his stated

Table 2.—*Dimensions of lower teeth of* Hyopsodus uintensis *from Wyoming, Utah and Saskatchewan, and* H. sholemi *new species, from Montana.*

Teeth statistics	*Hyopsodus uintensis*		*Hyopsodus sholemi*	
	L	W	L	W
P_4 Range	3.3–3.6	2.5–3.2	4.2	3.3
Mean	3.5	2.817	—	—
Number	5	6	1	1
SD	0.1124	0.2316	—	—
CV	3.497	8.221	—	—
M_1 Range	4.2–4.8	3.0–3.8	—	3.8
Mean	4.5	3.318	—	—
Number	12	11	—	1
SD	0.1906	0.2135	—	—
CV	4.235	6.434	—	—
M_2 Range	4.9–5.4	3.2–3.9	5.5	4.3
Mean	5.04	3.633	—	—
Number	15	15	1	1
SD	0.1505	0.2058	—	—
CV	2.987	5.666	—	—
M_3 Range	5.4–5.6	3.3–3.5	—	—
Mean	5.5	3.4	—	—
Number	2	2	—	—

* Holotype (CM 18851).

absence of a record of the lower dentition of *H. uintensis*. Osborn (1902) had, however, referred two lower jaws to *H. uintensis* along with the type partial maxilla. Although Russell (1965) correctly noted that a newly recovered M^1 of *H. fastigatus* (ROM 1681) was indistinguishable from M^1 of *H. uintensis*, he and Gazin (1968) maintained *H. fastigatus* for the Swift Current Creek material, citing the larger size of the isolated lower molars in comparison with those of *H. uintensis* from Badwater. Analysis of the greater sample of *H. uintensis* from Badwater and remeasurement of the Swift Current Creek material indicates that the type and referred specimens of *H. fastigatus* (except ROM 1684) from Saskatchewan do not differ significantly in size or crown morphology from *H. uintensis*. Accordingly, *H. fastigatus* is synonymized here with *H. uintensis*. Additionally, two (ROM 1686, 1687) of the three upper molars that Russell (1965) identified as *Epihippus?* sp. represent *H. uintensis*. ROM 1684 is not a molar of *Hyopsodus*.

The material from the Shoddy Springs locality that Gazin (1968) assigned to *H. fastigatus* is, as described below, distinct from *H. uintensis*, and referred to a new species. The *Hyopsodus* remains from

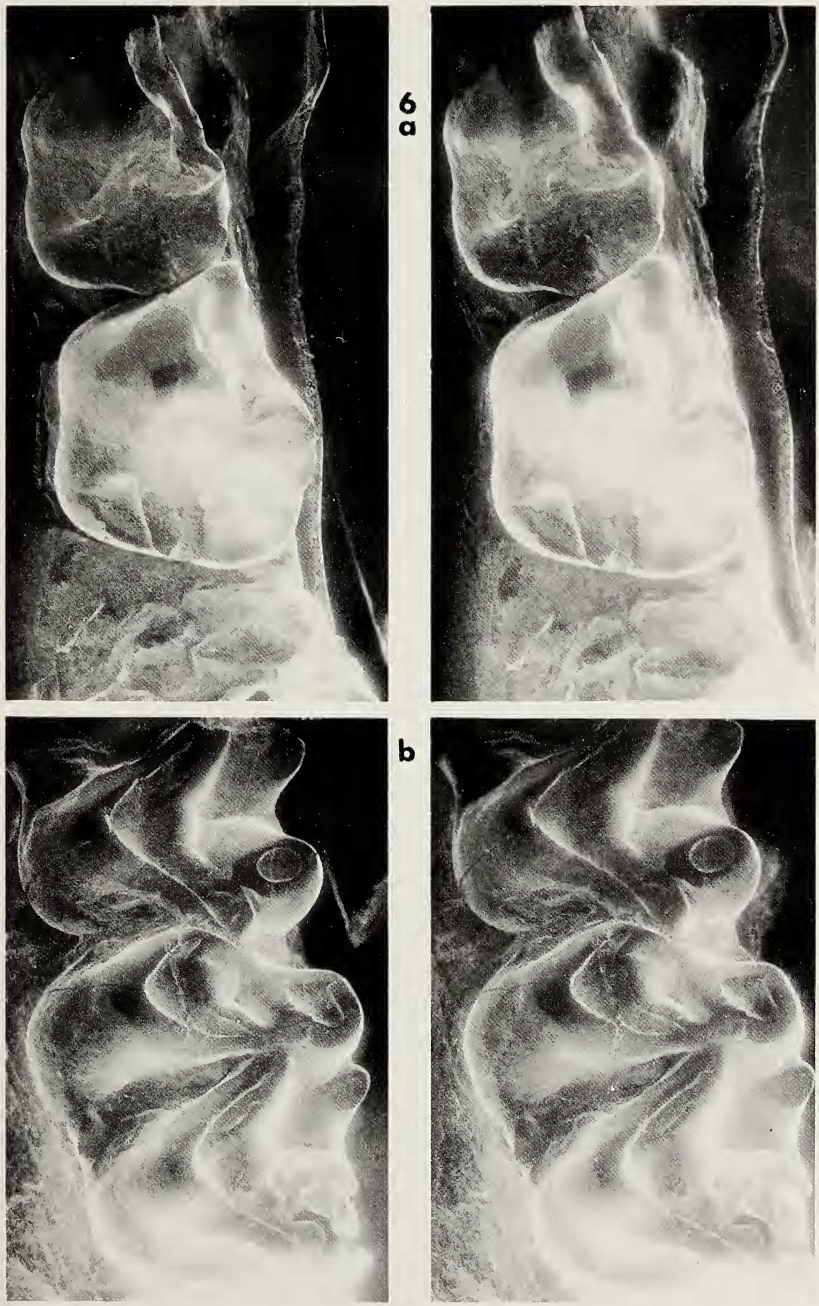


Fig. 6.—*Hyopsodus sholemi*, type, CM 18851. a) P_{3-4}; b) M_1 talonid, M_2.

Fig. 7.—*Hyopsodus sholemi*, USNM 23744 (part), RP^3-M^1.

the East Fork Basin (McKenna, 1972) are under study elsewhere and not considered here.

Hyopsodus sholemi, new species
(Figs. 6–8; Tables 1, 2)

Hyopsodus fastigatus Gazin, 1968 (in part).

Holotype.—CM 18851, partial left dentary with P_3-M_2, from Shoddy Springs locality, Climbing Arrow Formation, Montana.

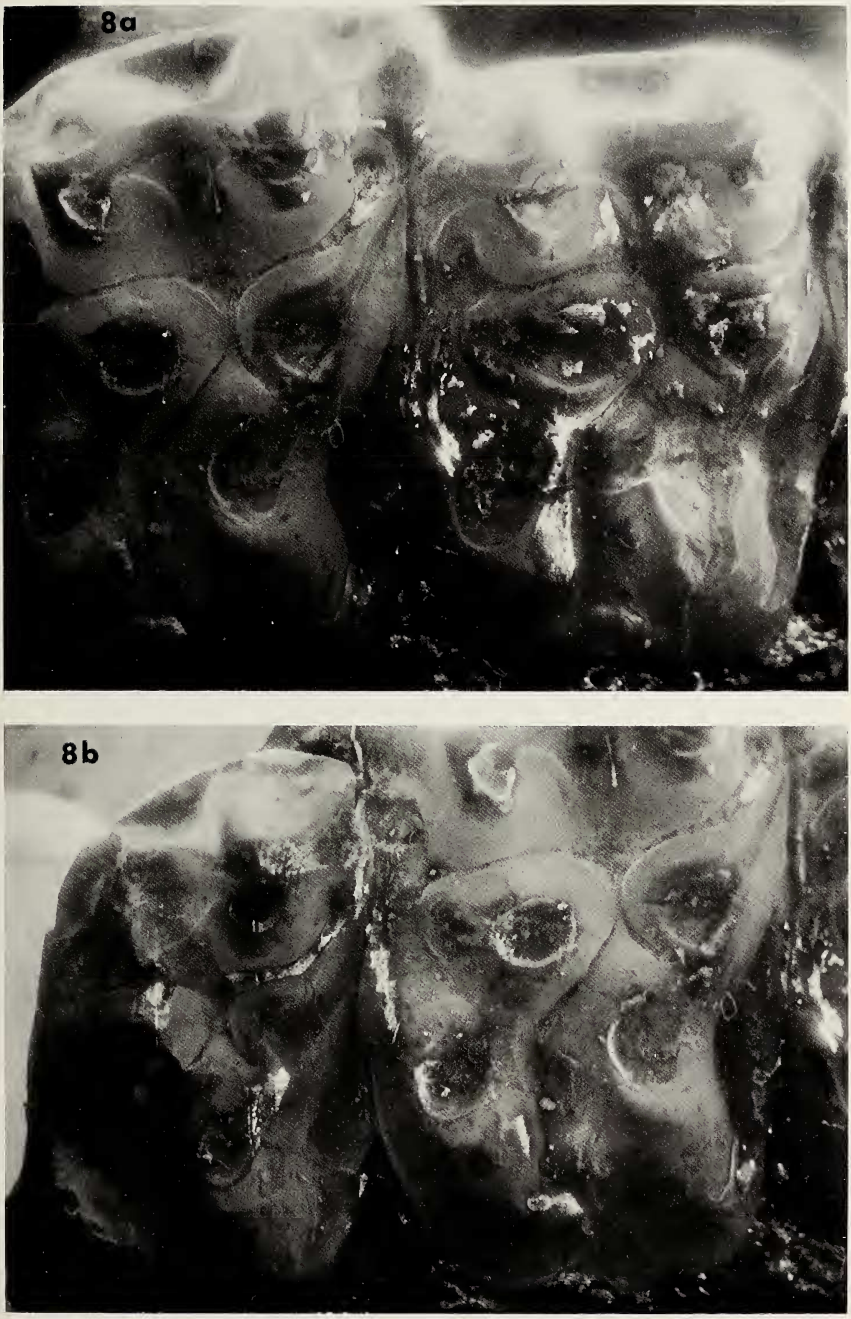


Fig. 8.—*Hyopsodus sholemi*, USNM 23744 (part); a) RM^{1-2}; b) RM^{2-3}.

Referred specimens.—M_1 or M_2, CM 21257; P^3-M^3, USNM 23744; M^{1-3}, CM 18849, 18850; M^3, CM 21258.

Locality.—Shoddy Springs, Climbing Arrow Formation, Montana (coordinates on file in the Section of Vertebrate Fossils, CMNH).

Known distribution.—Duchesnean of Montana.

Diagnosis.—Largest known species of *Hyopsodus*; most closely resembles *H. uintensis* in morphology of P_3^3-M_3^3; differs from *H. uintensis* as follows: P_3 more elongate, with stronger paracristed and definite metaconid; P_4 with broader talonid, especially at the lingual part of the base of the metaconid; P^3 quadrate (rather than triangular), more molariform, with expanded, squared-off, posterointernal corner of the crown; M^{1-3} more nearly square, with larger L/W ratio.

Etymology.—Named for Mr. Sholem Krishtalka.

Remarks.—Like *H. uintensis*, the molars of *H. sholemi* differ from all other species of *Hyopsodus* in exhibiting marked lophodonty, oblique skewing of the trigonid, an enlarged entoconid, and a deep valley that completely separates the protocone and large hypocone. Compared to *H. uintensis*, P_3^3-M_3^3 of *H. sholemi* are significantly larger, P^3 is squared-off lingually by an expansion of the posterointernal corner of the crown, and P_{3-4} are more molariform.

H. sholemi is known only from Shoddy Springs, Montana, from material previously (Gazin, 1968) identified as *H. fastigatus*. The holotype and remaining specimens of *H. fastigatus* from the Swift Current Creek beds, Saskatchewan, were referred above to *H. uintensis*.

CONCLUSIONS

The Badwater Uintan localities preserve remains of a single species of *Hyopsodus*, *H. uintensis*, the type of which is from Uinta C deposits, Utah. Material from the Uinta B White River Pocket locality previously described as *H. uintensis* shares the diagnostic features of and is referred to *H. paulus*, a species formerly known only from Bridgerian sediments. *H. fastigatus*, described from Saskatchewan and Montana, is not valid. The Swift Current Creek material, including the holotype, belongs to *H. uintensis*. The remains from the Climbing Arrow Formation compose the hypodigm of a new species, *H. sholemi*.

H. uintensis and *H. sholemi* are derived compared to all other known species of *Hyopsodus*—P_{3-4}^{3-4} are more molariform, and the molars extremely lophodont. Additional specializations are a large hypocone and deep hypocone-protocone valley on M^{1-2}, and an obliquely oriented trigonid on M_{1-3}. *H. sholemi* is significantly larger than *H. uintensis*, with a more molariform P^3 and P_{3-4}.

H. uintensis is currently known from late Uintan localities in Wy-

oming, Utah, and Saskatchewan. *H. sholemi*, from Montana, may be Duchesnean. Other elements of the Shoddy Springs fauna imply an age comparable to that of the Duchesnean Badwater locality 20 (Krishtalka and Black, 1975) which has been dated at 41 my. The absence of *Hyopsodus* from locality 20 has paleoecological implications that will be discussed elsewhere, in a final review of the Badwater fauna.

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Drs. Mary R. Dawson and Robert M. West provided helpful discussions and reviewed the manuscript. Dr. West also greatly facilitated comparisons between Bridgerian and Uintan material of *Hyopsodus*. Dr. Malcolm C. McKenna kindly made available specimens of *Hyopsodus* in the American Museum of Natural History, including undescribed material from the Tepee Trail Formation. This study was supported by NSF grants GB-1266, GB-4089, GB-7081, GB-30840X, and DEB-76-18760.

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